(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 856 871 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.08.1998 Bulletin 1998/32

(51) Int. Cl.6: H01J 61/42, H01J 61/44, H01J 61/48

(21) Application number: 97101366.9

(22) Date of filing: 29.01.1997

(84) Designated Contracting States:
DE FR GB IT NL

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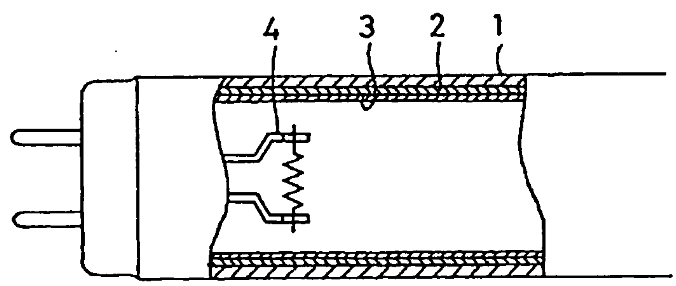
(54) Fluorescent lamp

(57) First and second phosphor coatings composed of one or more types of phosphor are layered on the inner surface of the glass bulb of a fluorescent lamp. The first phosphor coating on the glass bulb side is composed of a phosphor which has a long afterglow property and is applied at 0.2 mg per 1 cm^2, and the second phosphor coating is composed of a halophosphate phosphor or rare-earth phosphor. The phosphor coating having a long afterglow property may include, for example, a europium-activated strontium aluminate phosphor.

Fig. 1



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Printed by Xerox (UK) Business Services
2.16.3/3.4

Description

Background of the Invention:

1. Field of the Invention:

This invention relates to a fluorescent lamp, and particularly to the improvement of a fluorescent lamp that emits an afterglow sufficient to allow discernment of objects for at least ten minutes after the lamp is extinguished.

2. Description of the Related Art:

Fluorescent lamps for illumination purposes are generally constructed by forming a phosphor coating composed of, for example, a halophosphate phosphor or rare-earth phosphor on the inner surface of a glass bulb. For example, a straight-tube 40-watt fluorescent lamp using a halophosphate phosphor produces a luminous intensity of 2700-3100 (lm) and is widely used for such purposes as lighting offices, large stores, theaters, baths, and underground shopping malls.

Particularly in areas in which large numbers of people gather such as large stores, theaters, and underground shopping malls, protecting lives is a priority and provision must be made for safe and speedy evacuation even in the event of a blackout caused by a fire, earthquake or other disaster.

Accordingly, for facilities such as large stores, theaters, and underground shopping malls which meet set conditions with regard to the amount of space they occupy or the number of people that use them, the Fire Law and Building Standards Law stipulate the provision of guide lights or emergency lighting.

Such guide lights or emergency lighting are constructed to allow use of a commercial power source during normal operation, but during emergencies (blackouts), to allow use of an internal battery to light a fluorescent lamp or light bulb at an illuminance of 1 lx or greater for at least 20-30 minutes. During emergencies, therefore, a minimum illuminance at the ground surface of 1 lx or greater can be ensured to enable safe and speedy evacuation even when the commercial power source is interrupted and normal lighting apparatus are nonfunctional. However, such guide lights or emergency lighting are costly and, compared to normal lighting fixtures, few in number. As an example, if passageway guide lights are arranged along lower wall surfaces, people far from the wall will be a considerably less aware of the passageway guide lamps than people close to the wall during the confusion of an evacuation, and this reduced awareness may hinder the speed of evacuation. On the other hand, in ordinary homes where installation of such guide lights and emergency lighting is not required, smooth and speedy evacuation may be hindered by the lack of light during a blackouts caused by a disaster, and evacuation of children or disabled persons may be hindered.

The present applicants therefore proposed a fluorescent lamp having a phosphor coating composed of one or more varieties of phosphors on the inner surface of a glass bulb, this phosphor coating being a mixture including at least 0.2 mg per 1 cm^2 of a phosphor having a long afterglow property.

According to this proposal, by using such a fluorescent lamp as a fluorescent lamp for ordinary lighting purposes, an illuminance of at least 0.05 lx, which allows discernment of objects, can be obtained even after the passage of 500 seconds after the fluorescent lamp has been extinguished, and the fluorescent lamp therefore provides the functions of both a guide light in a blackout as well as an ordinary night-light.

However, in ordinary use, this fluorescent lamp produces a brightness of only 40% that of ordinary fluorescent lamps for lighting purposes, and this leads to the problem that the number of lamps installed for ordinary use must be increased to attain the desired illuminance at floor level, thereby increasing the financial burden of using such lamps.

Summary of the Invention:

The object of the present invention is to provide a fluorescent lamp that allows an improvement in the degree to which light can be put to practical use through a comparatively simple construction and with no loss in extended afterglow property. To achieve the above-described object, the present invention is a fluorescent lamp formed by layering first and second phosphor coatings composed of one or more types of phosphors on the inner surface of a glass bulb, wherein the first phosphor coating on the glass bulb side is formed from a phosphor having a long afterglow property.

As one modification of the present invention, the application amount of phosphor having a long afterglow property of the first phosphor coating is set to at least 0.2 mg per 1 cm^2, the second phosphor coating is formed from a phosphor having a long afterglow property, and the second phosphor coating is formed from one or more rare-earth phosphors.

As another modification of the present invention, an ultraviolet light reflection layer is formed between the glass bulb and first phosphor coating, and this ultraviolet light reflection layer is constituted from alumina or magnesia.

As still another modification of the present invention, a transparent conductive film is formed between the glass bulb and the first phosphor coating, and in addition, an ultraviolet light reflection layer is formed between this conductive film

and the first phosphor coating.

As yet another modification of the present invention, the outer surface of the glass bulb is covered by a transparent protective layer, and in addition, this protective layer is constituted from a resin tube.

The above and other objects, features, and advantages of the present invention will become apparent from the following description based on the accompanying drawings which illustrate examples of preferred embodiments of the present invention.

Brief Description of the Drawings:

Fig. 1 is a sectional view showing the principal components of the first embodiment of a fluorescent lamp according to the present invention.

Fig. 2 is a sectional view showing the principal components of the second embodiment of the present invention.

Fig 3 is a sectional view showing the principal components of the third embodiment of the present invention.

Fig. 4 is a sectional view showing the principal components of the fourth embodiment of the present invention.

Fig. 5 is a graph showing the relation of the afterglow illuminance to the time elapsed after extinguishing for an embodiment of the present invention.

Fig. 6 is an enlarged view of the illuminance scale of Fig. 5.

Detailed Description of the Preferred Embodiments:

The first embodiment of the present invention will next be explained with respect to the fluorescent lamp shown in Fig. 1 which employs mercury discharge. In this figure, a first phosphor coating 2 composed of at least one type of phosphor having a long afterglow property is formed on the inner surface of glass bulb 1. This first phosphor coating 2 is formed at an application amount of at least 0.2 mg per 1 cm^2. As the above-described phosphor having long afterglow property, a chemical compound is used that can be represented by, for example, the general formula MAl_2O_4, wherein M is a light-accumulating phosphor in which a chemical compound composed of at least one metal element selected from the group composed of calcium, strontium, and barium is made the mother crystal, and in addition to the use of europium (Eu) as an activator, an element such as dysprosium (Dy) or neodymium (Nd) is used as a co-activator. The average particle diameter of these phosphors is set to, for example, 2-12 μm (according to the Fischer Subsieve Sizer Method(FSSS)).

Second phosphor coating 3 composed of one or more phosphors is layered over first phosphor coating 2. An application amount within the range of 2-5 mg per 1 cm^2 is effective for this second phosphor coating 3, with 3.3 mg being the optimum application amount, and the layer is formed by mixing one or more types of, for example, halophosphate phosphors ($Ca_{10}(PO_4)_6FCl$: Sb/Mn, etc.) or rare-earth phosphors (Y_2O_3 : Eu, $LaPO_4$: Ce/Tb, $(SrCaBaMg)_5(PO_4)_3Cl$: Eu, etc.). In forming these phosphor coatings 2 and 3, the layer thickness can be made relatively uniform by setting the application direction at the time of forming second phosphor coating 3 opposite to the application direction at the time of forming first phosphor coating 2. Finally, electrodes 4 are arranged at both ends of glass bulb 1.

According to this embodiment, of the first and second phosphor coatings 2 and 3 formed in a layered state on the inner surface of glass bulb 1, at least second phosphor coating 3 on the discharge path side is constituted from a phosphor such as a rare-earth phosphor used in ordinary fluorescent lamps for lighting purposes, and consequently, when the lamp is turned on, this phosphor is efficiently excited by ultraviolet light of, for example, 253.7 nm wavelength, and a significant increase in brightness can therefore be realized. In addition, first phosphor coating 2, being formed on the glass bulb side, is excited by ultraviolet light passing through second phosphor coating 3 and also emits light. On the other hand, when the lamp is turned off, nearly all emitted light is emitted directly to the exterior from glass bulb 1. Accordingly, light emitted from first phosphor coating 2 directly toward the glass bulb side can be emitted to the exterior with nearly no attenuation and can be effectively employed as a guide light in emergencies or for other purposes. In particular, because the application amount of a phosphor having a long afterglow property is set to at least 0.2 mg per 1 cm^2, first phosphor coating 2 can maintain an illuminance on the order of 0.05 lx, which allows discernment of objects, over a long time interval after the fluorescent lamp is extinguished. Consequently, the application of such fluorescent lamps in lighting fixtures for ordinary households or in ordinary lighting fixtures in areas where the fire law or building standards law stipulates the installation of guide lights or emergency lights can enable smooth and speedy evacuation even in blackouts caused by disasters thanks to the produced afterglow, which is of a brightness that allows discernment of objects. In addition, the use of the fluorescent lamp of the present invention obviates the use of the miniature bulbs on the order of 5 W which are often mounted in household lighting fixtures for use as night-lights, thereby allowing both a reduction in the cost for light fixtures as well as a reduction in electrical power use.

Fig. 2 shows another embodiment of the present invention in which a transparent ultraviolet light reflection layer 5 is formed between glass bulb 1 and first phosphor coating 2. This ultraviolet light reflection layer 5 is formed from, for example, alumina (Al_2O_3) or magnesia (MgO) having an average particle diameter of less than, for example, 0.1 μm,

and preferably between 30 and 50 nm.

First and second phosphor coatings 2 and 3 are excited by ultraviolet light of, for example, 253.7 nm wavelength produced by discharge between electrodes 4, but while the phosphor located on the discharge path side is efficiently excited, the phosphor located on the glass bulb side and farther from the discharge path tends to be excited at a reduced level of efficiency. However, according to this embodiment, ultraviolet light that passes through first and second phosphor coatings 2 and 3 is reflected by ultraviolet light reflection layer 5, and phosphor located on the glass bulb side is therefore excited both by ultraviolet light passing through and by ultraviolet light that is reflected back. The luminous efficacy of this lamp can consequently be increased.

In addition, by forming ultraviolet light reflection layer 5 from, for example, alumina allows suppression of contact by mercury with glass bulb 1, thereby reducing or eliminating changes in color due to solarization.

Fig. 3 shows a different embodiment of the present invention in which a transparent conductive film 6 is formed between glass bulb 1 and first phosphor coating 2. This conductive film 6 is formed by, for example, spray application of a liquid containing tin chloride onto the inner surface of glass bulb in a heated state. This film 6 has a resistance of, for example, 1-1000 kΩ level.

This embodiment can be applied to lighting fixtures equipped with a ignition circuit device for rapid-start lighting, and is ideal for use in locations such large stores, theaters, and underground shopping malls where a reduction in time for maintenance is desirable.

In particular, if ultraviolet light reflection layer 5 as shown in Fig. 2 is formed between glass bulb 1 and conductive film 6, not only can an improvement in brightness be achieved, but color changes brought about by decay of the crystal structure of the film 6 due to contact of mercury with the tin of the film can also be reduced or eliminated, thereby allowing an improvement in the outer appearance of the fluorescent lamp. Fig. 4 shows yet another embodiment of the present invention in which a protective layer 7 is formed on the outer surface of glass bulb 1. This protective layer 7 is composed of, for example, a resin material such as a polyethylene terephtalate (PET) having a thickness set to, for example, 100-150 µm. This protective layer 7 is formed by first preparing a tube form, and after inserting glass bulb 1, heating to 150-200°C to cause the tube to shrink and come into close contact with the outer surface of glass bulb 1. In particular, if an ultraviolet light absorbent such as titanium oxide (TiO_2) is mixed into protective layer 7, not only can the light resistance of protective layer 7 be improved, but the protective layer 7 can also serve as an ultraviolet light blocking layer. This construction may also be applied to the fluorescent lamps shown in Figs. 2 and 3.

According to this embodiment, a protective layer 7 made of resin is formed on the outer surface of glass bulb 1, and this protective layer 7 not only prevents glass bulb 1 from shattering should breakage occur in an emergency, but also allows emission of enough light when the bulb is broken to enable discernment of objects, thereby enabling smooth and speedy evacuation. Furthermore, this fluorescent lamp may be removed from a light fixture and used as a substitute for a flashlight, an example which illustrates that the present invention can be of service in countless ways beyond serving as a guide light for evacuation.

The present invention is not restricted to any of the above-described embodiments, and may of course be applied to straight-tube fluorescent lamps other than a 40-watt model, as well as to circular fluorescent lamps, compact fluorescent lamps, and globe fluorescent lamps. As a phosphor having a long afterglow property, any substance having long afterglow properties may be used in addition to those described in the embodiments hereinabove such as a europium-, neodymium-, and yttrium-activated calcium aluminate phosphor ($CaAl_2O_4$: Eu/Nd/Y). Further, in triphosphor fluorescent lamps, of the three or more types of phosphors within the second phosphor coating, at least one type can be exchanged for a phosphor having long afterglow properties.

Next, the results of test measurement of each of the embodiments of the fluorescent lamp according to the present invention will be presented.

The inventors of the present invention first fabricated an FL40 fluorescent lamp using a cerium- and terbium-activated lanthanum phosphate phosphor ($LaPO_4$: Ce/Tb --- Phosphor A) having a light emission peak at 544 nm wavelength and a europium- and dysprosium-activated strontium aluminate phosphor ($SrAl_2O_4$: Eu/Dy --- Phosphor B) having a long afterglow property and moreover, having a light emission peak of 510 nm wavelength, and then measured total luminous flux to obtain the results shown in the following Chart 1. The application amounts of the phosphors was a uniform 4.0 mg/cm^2 for each of the first and second phosphor coatings.

Table 1

1st phosphor coating	2nd Phosphor coating	Total luminous flux (relative value)
A Phosphor	B Phosphor	90
B Phosphor	A Phosphor	100

It is clear from the chart, if total luminous flux for combined use of phosphor A in the second phosphor coating and phosphor B in the first phosphor coating is 100, total luminous flux for a reverse combination decreases to 90%. These results demonstrate that disposing a phosphor having good luminous efficacy on the discharge path side enables an overall improvement in efficiency. In a fluorescent lamp using the former combination in which an ultraviolet light reflecting layer composed of alumina is formed between the glass bulb and the first phosphor coating, total luminous flux is increased by about 3%.

In an FL40 fluorescent lamp using a combination of phosphor A in the second phosphor coating and phosphor B in the first phosphor coating wherein the application amount of phosphor A is a constant 4 mg/cm^2 and the application amount of phosphor B is varied over a range from 0 to 8.0 mg/cm^2, measurement of total luminous flux and illuminance 300 seconds following extinguishing the lamp produced the results shown in chart 2. Here, illuminance was measured by placing a light meter 10 mm away from the center portion of the fluorescent lamp.

Table 2

Lamp No.	Application amount of 1st phosphor coating (mg/cm^2)	Total luminous flux (relative value)	Afterglow illuminance (lx)
1	0	100	0
2	0.1	99	0.03
3	0.2	98	0.05
4	0.5	96	0.09
5	1.0	94	0.13
6	2.0	92	0.17
7	3.9	90	0.21
8	5.7	80	0.25
9	8.0	65	0.32

As is clear from this chart, although total luminous flux decreases as the application amount of phosphor B increases, the afterglow illuminance increases. The illuminance that would allow discernment of objects in the event of, for example, a blackout, has been determined through testing to be about 0.05 lx, and it can therefore be seen that the application amount of phosphor B required to obtain this intensity is at least 0.2 mg/cm^2. Although a fluorescent lamp having total luminous flux at least 50% that of an ordinary fluorescent lamp can reasonably serve for practical use, an application amount of 8.0 mg/cm^2 should be considered the limit from the standpoint of economical use.

The inventors of the present invention additionally fabricated an FL40 fluorescent lamp by applying to the inner surface of a glass bulb a europium- and dysprosium- activated strontium aluminate phosphor ($Sr_4Al_{14}O_{25}$: Eu/Dy --- Phosphor C) having a light emission peak of 490 nm wavelength as the first phosphor coating, and as the second phosphor coating, prepared a mixture according to the proportions shown in chart 3 including a europium-activated yttrium oxide phosphor (Y_2O_3 : Eu --- phosphor D) having a light emission peak of 622 nm wavelength, phosphor A, and a europium-activated strontium-calcium-barium-magnesium phosphate phosphor ($(SrCaBaMg)_5(PO_4)_3Cl$: Eu ---Phosphor E) having a light emission Peak of 453 nm wavelength. The application amounts of the first and second phosphor coatings were 5.3 and 3.4 mg/cm^2, respectively.

Table 3

Phosphor coating	Phosphors used	Proportions (wt%)	Application amount (mg/cm^2)
1st coating	C Phosphor	—	5.3
2nd coating	D Phosphor	32.2	3.4
	A Phosphor	23.9	
	E Phosphor	43.9	

Measurements of each of the characteristics of this fluorescent lamp gave a total luminous flux of 2842 lm. Total luminous flux for a fluorescent lamp of the prior art not provided with the first phosphor coating was 3200 lm. Illuminance with respect to time elapsed following extinguishing the lamp (afterglow property) is shown in Figs. 5 and 6. Fig. 6 is substantially identical to Fig. 5 and differs only in that the illuminance scale of the vertical axis has been magnified. As is clear from Figs. 5 and 6, the afterglow illuminance is 0.2 lx even 500 seconds after extinguishing the lamp, and this level of illuminance allows ample discernment of objects, enabling a smooth and speedy evacuation. Moreover, this fluorescent lamp maintained an illuminance of more than 0.05 lx even after the passage of 2 hours.

As explained hereinabove, according to the present invention, of the first and second phosphor coatings formed in a layered state on the inner surface of a glass bulb, at least the second phosphor coating on the discharge path side is constructed from a phosphor such as a rare-earth phosphor used in ordinary fluorescent lamps for illumination purposes, and as a result, this phosphor coating is efficiently excited by ultraviolet light of, for example, 253.7 nm wavelength when the lamp is turned on, thereby allowing a significant increase in brightness.

On the other hand, the first phosphor coating is formed such that the application amount is 0.2 mg or more per 1 cm^2 on the glass bulb side, and consequently, this coating is excited by ultraviolet light passing through the second phosphor coating and emits light. Nearly all light emitted when the bulb is extinguished is emitted directly toward the exterior from the glass bulb. Accordingly, light emitted from the first phosphor coating can be directed toward the exterior with virtually no attenuation and can be effectively used as a guide light in emergencies or as a night-light. In particular, if an ultraviolet light reflection layer is formed between the glass bulb and the first phosphor coating, ultraviolet light that would ordinarily have escaped past the glass bulb is reflected back by the reflection layer and acts to excite the phosphor, thereby contributing an improvement in brightness. If a translucent conductive film is additionally formed between the glass bulb and the first phosphor coating, the start-up characteristics of the fluorescent lamp can be improved.

Finally, if a protective layer made of, for example, resin is formed on the outer surface of the glass bulb, not only can shattering of the bulb be prevented if the bulb should break in an emergency, but the bulb can still produce sufficient light to allow discernment of objects even in a broken state, and can also be removed from the light fixture and used as a substitute for a flashlight.

It is to be understood, however, that although the characteristics and advantages of the present invention have been set forth in the foregoing description, the disclosure is illustrative only, and changes may be made in the arrangement of the parts within the scope of the appended claims.

Claims

1. A fluorescent lamp wherein first and second phosphor coatings comprising one or more types of phosphors are formed on the inner surface of a glass bulb, said first phosphor coating on the glass bulb side being formed from a phosphor having a long afterglow property.

2. A fluorescent lamp according to claim 1 wherein the application amount of said phosphor having a long afterglow property of said first phosphor coating is at least 0.2 mg per 1 cm^2.

3. A fluorescent lamp according to claim 1 or 2 wherein said first phosphor coating is formed of a chemical compound that can be represented by the general formula MAl_2O_4, wherein M is a light-accumulating phosphor in which a chemical compound composed of at least one metal element selected from the group composed of calcium, strontium, and barium is made the mother crystal, and in addition to the use of europium (Eu) as an activator, an element such as dysprosium (Dy) or neodymium (Nd) is used as a co-activator, the average particle diameter of these phosphors being set to 2-12 μm.

4. A fluorescent lamp according to claim 1 wherein the second phosphor coating is formed from a phosphor having a long afterglow property.

5. A fluorescent lamp according to claim 1 wherein said second phosphor coating is formed from one or more rare-earth phosphors and the application amount of said second phosphor coating is within a range of 2 to 5 mg per/cm^2.

6. A fluorescent lamp according to claims 4 or 5 wherein said second phosphor coating is formed by mixing one or more types of halophosphate phosphors ($Ca_{10}(PO_4)_6FCl$: Sb/Mn, etc.) or rare-earth phosphors (Y_2O_3 : Eu, $LaPO_4$: Ce/Tb, $(SrCaBaMg)_5(PO_4)_3Cl$: Eu, etc.).

7. A fluorescent lamp according to claim 1 wherein an ultraviolet light reflection layer is formed between said glass bulb and said first phosphor coating.

8. A fluorescent lamp according to claim 1 wherein a translucent conductive film is formed between said glass bulb and said first phosphor coating, said translucent conductive film being formed by spray application of a liquid containing tin chloride onto the inner surface of glass bulb in a heated state and having a resistance of 1-1000 kΩ level.

9. A fluorescent lamp according to claim 8 wherein an ultraviolet light reflection layer is further formed between said conductive film and said first phosphor coating.

10. A fluorescent lamp according to claim 7 or 9 wherein said ultraviolet light reflection layer is constituted from alumina or magnesia having an average particle diameter of less than 0.1μm.

11. A fluorescent lamp according to claim 1 wherein the outer surface of said glass bulb is further covered by a transparent protective layer.

12. A fluorescent lamp according to claim 9 wherein said protective layer is constituted from a resin tube.

Fig. 1

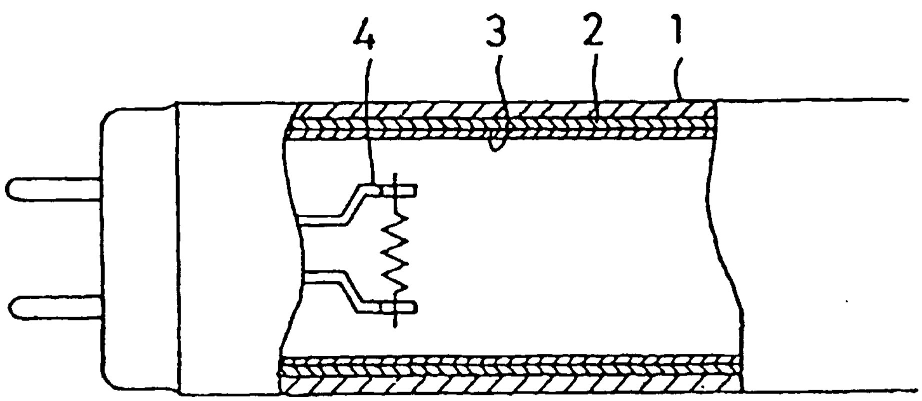


Fig. 2

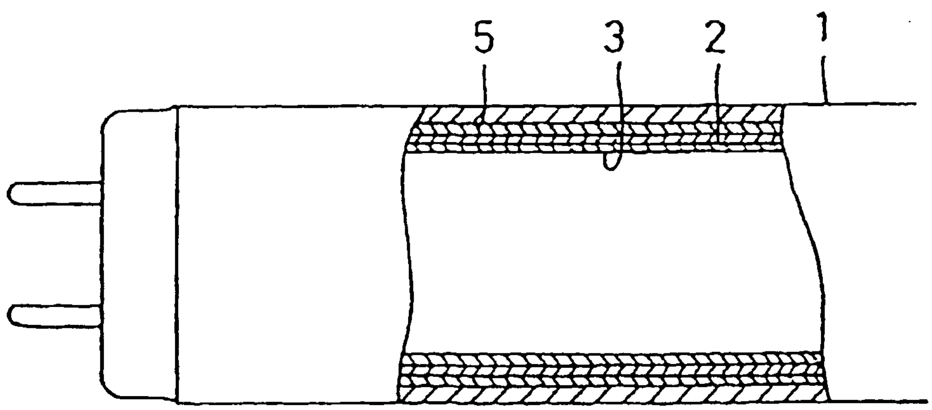


Fig. 3

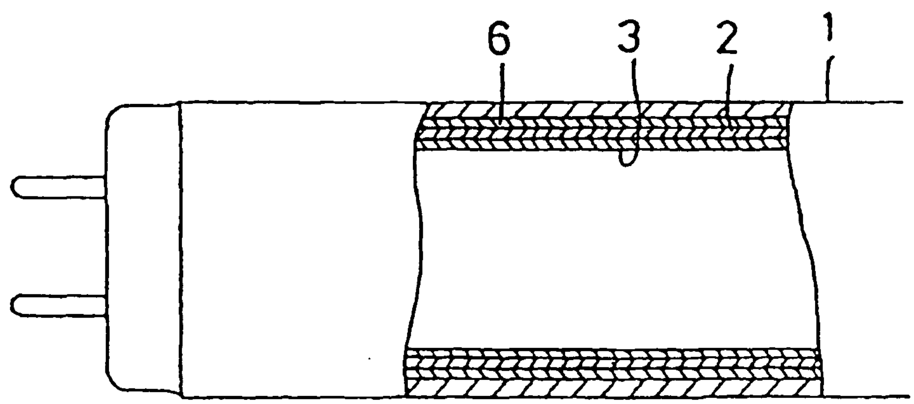


Fig. 4

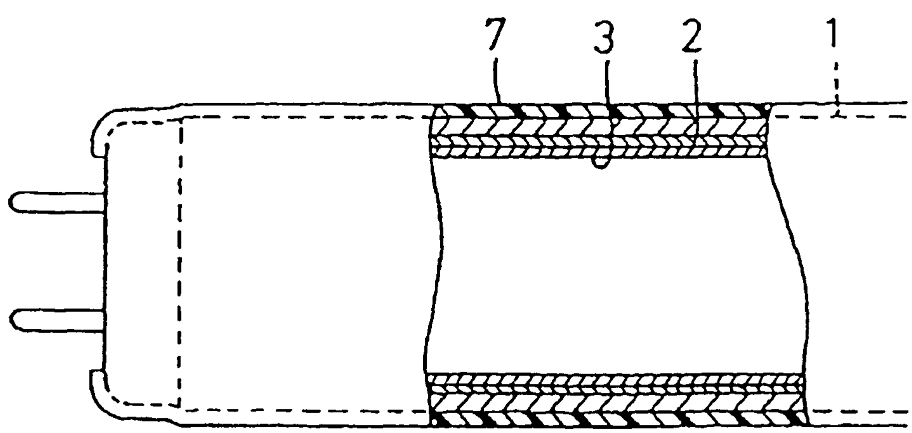


Fig. 5

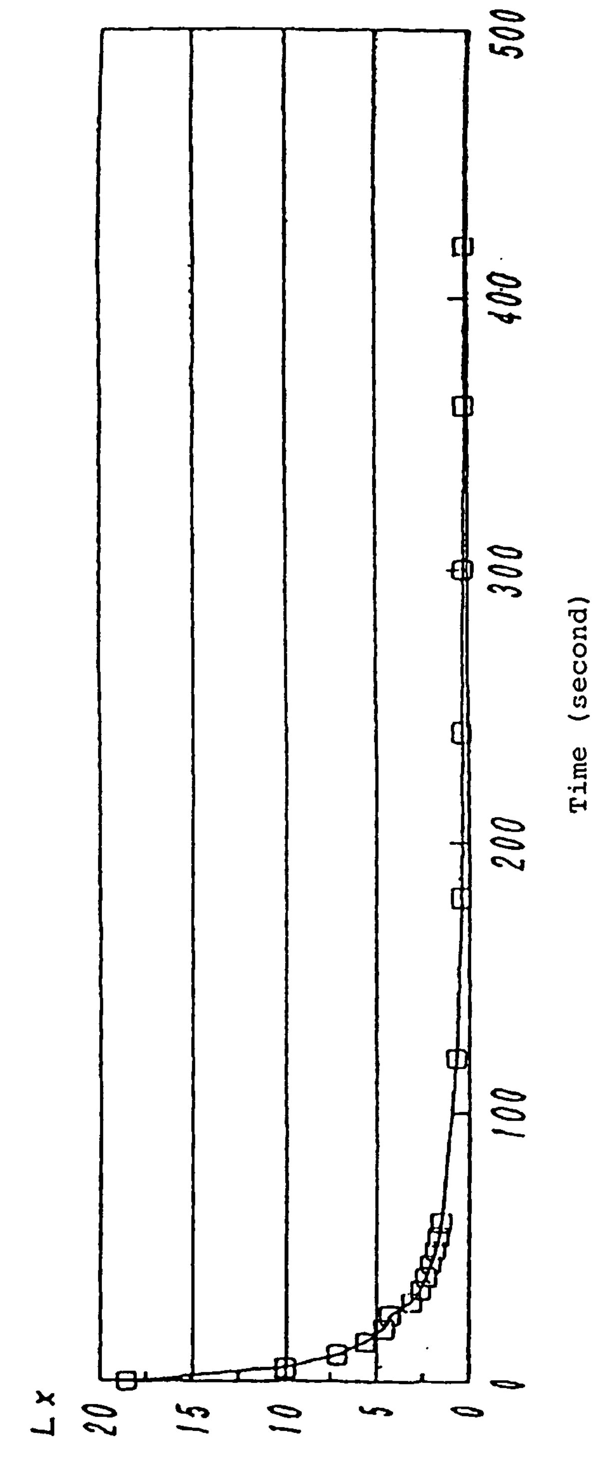
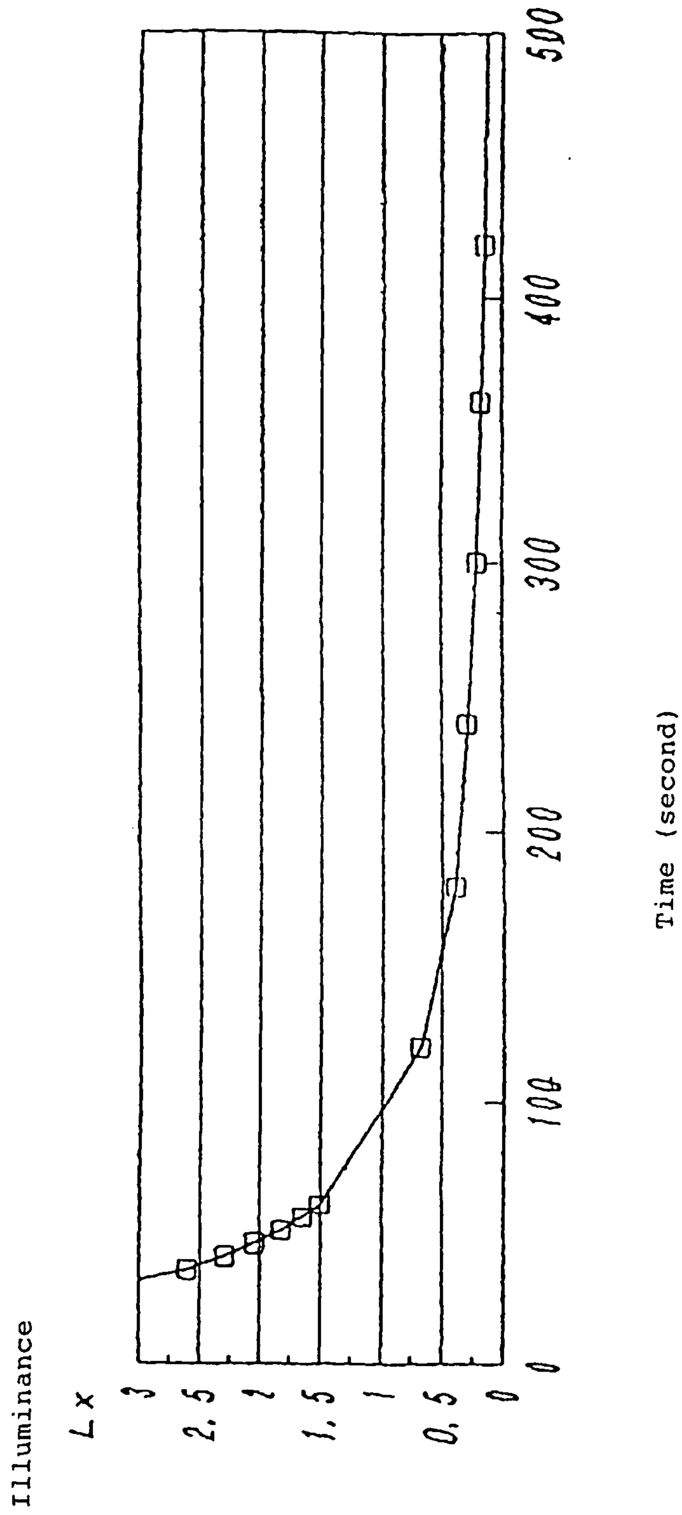


Fig. 6



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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 1366

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US 4 705 986 A (K.IWAMA & AL) * the whole document * ---	1,3,6	H01J61/42 H01J61/44 H01J61/48
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	1 July 1997	Drouot, M-C

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A	DATABASE WPI Section Ch, Week 7737 Derwent Publications Ltd., London, GB; Class L03, AN 77-65871Y XP002034092 & JP 52 093 184 A (NEC SYLVANIA CORP) , 5 August 1977 * abstract * -----	8	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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